

A NEW AND IMPROVED DRY BEAN SIMULATION MODEL : CROPGRO-DRY BEAN

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INTRODUCTION

The model CROPGRO-DRY BEAN is a process oriented computer model that simulates growth, development and yield of dry bean (*Phaseolus vulgaris* L.) as a function of environmental conditions and crop management scenarios. CROPGRO is based on the GRO models for dry bean (BEANGRO V1.01), peanut (PNUTGRO V1.02) and soybean (SOYGRO V5.42) (Hoogenboom, 1992, 1994). However, various deficiencies and weaknesses were found in BEANGRO Version 1.01 (Hoogenboom et al., 1991, 1994). The objective of this paper is to present the improvements made in CROPGRO.

MODEL DESCRIPTION

Development CROPGRO simulation of dry bean growth and development starts at planting and terminates at harvest maturity or at the harvest date as defined by the user. The model uses a daily time step to calculate and update all soil and plant processes. After planting the model predicts emergence, first leaf appearance, flower initiation, start of flowering, first pod and first seed occurrence, physiological maturity, and harvest maturity. The model also predicts the vegetative growth stage by calculating the number of leaves on the main stem. The development processes are a function of both temperature and photoperiod; three different temperature functions are defined for the critical growth phases : vegetative development, the period from emergence to first seed, and the period between first seed and physiological maturity.

Cultivar Characteristics A special cultivar input file allows the user to define the sensitivity of each cultivar to photoperiod, the optimum duration of each growth phase, such as emergence to flowering, flowering to first seed, and first seed to physiological maturity, and some other critical parameters. A second input file, i.e. the ecotype file, defines characteristics common among a group of cultivars, such as seed size. A third input file, i.e. the species file, defines the general characteristics of the dry bean crop. These include the temperature responses for development, pod set, seed filling, photosynthesis and partitioning; the effect of drought and nitrogen stress on growth, development, and other processes; chemical composition of leaves, stems, roots, seeds, and shells; and other generic dry bean variables.

Growth CROPGRO has two options to predict daily photosynthetic rates. The first one calculates light interception and canopy photosynthesis on a daily basis. This option is similar to the function included in BEANGRO. The second option calculates light interception and photosynthesis on an hourly basis (Boote and Loomis, 1991). After calculating gross photosynthesis and daily maintenance respiration, the model estimates potential carbon partitioning to both vegetative and reproductive structures. This information is used to estimate nitrogen demand required to synthesize protein used for building new tissue. Total nitrogen demand is then used to calculate nitrogen uptake,

nitrogen fixation, and nitrogen mobilization. These nitrogen processes have been added to CROPGRO and allow for a dynamic simulation of nitrogen fixation as a function of both plant conditions and soil factors, such as temperature, drought and water logging (Hoogenboom et al., 1990). Both drought and nitrogen stresses can affect gross photosynthesis and partitioning.

Transpiration Potential evapotranspiration is calculated according to the Priestley-Taylor method (Priestley and Taylor, 1972), which uses daily air temperature and solar radiation as weather inputs. A new option has been added to calculate potential evapotranspiration, based on the FAO-Penman method (Doorenbos and Pruitt, 1977). Actual transpiration is a function of potential evapotranspiration, leaf area index, and root water extraction.

Soil Water and Nitrogen The soil water balance of the new CROPGRO model has not been modified; it is based on the one-dimensional soil water balance model developed by Ritchie (1985). The soil nitrogen balance section is a new feature, which has been added to be able to calculate nitrogen uptake. The soil nitrogen functions are based on the CERES-Wheat V2.1 model (Godwin et al., 1989). This soil nitrogen model accounts for nitrate and urea movement in the soil, soil nitrogen mineralization and immobilization, and nitrification and denitrification (Godwin and Jones, 1991). CROPGRO includes the option to simulate different nitrogen fertilizer management scenarios.

Pest Effects A generalized method for simulating pest damage by the model was developed (Batchelor et al., 1993). Twenty-one coupling points are identified where pests can potentially affect growth and development of the various dry bean processes in the model. However, the model does not simulate actual pest dynamics. Pest damage can be induced by input of field-observed damage information or for field-measured pest populations. Pest and pest damage coefficients are defined in a special pest parameter file. These coefficients are defined through the coupling points in the crop model and the damage rates associated with a unit of pest input.

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